THE FeII OPTICAL EMISSION IN AGN

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We investigated the FeII optical emission in a sample of about 220 low-redshift quasars and luminous Seyfert 1 galaxies. We found that a scaled and broadened FeII template based on the I Zw 1 spectrum satisfactorily reproduce the FeII emission of almost all AGN of our sample. We also confirm that FWHM of Hβ and FeIIλ4570 are tightly correlated. However, the correlation takes two slightly different forms: (a) if FWHM(Hβ) $\leq$ 4000 km s^{-1} (Population A), the width of FeII and Hβ is statistically indistinguishable, while the FWHM(FeIIλ4570) is systematically lower than that of Hβ if FWHM(Hβ) $\geq$ 4000 km s^{-1} (Population B). This suggests that FeII emission in Pop. B sources may come from the outer part of Hβ emitting region, where the ionization degree is lower.

1 Introduction

FeII emission has not been fully exploited as a diagnostic, because the complexity of the Fe^+ atom hampers reliable modeling. It was long ago realized the the FeII is emitted in the BLR. Strong FeII emission requires high density ($n_e \geq 10^9$ cm^{-3}, high column density and low temperature ($T_e \approx 5000$ K; [1]). These conditions are thought to be met in a partially ionized region within the BLR created by the strong X-ray emission in AGN ([2], [3] and [4]). The main observational evidence for BLR FeII emission is the profile FWHM similarity between FeIIλ4570 and the Broad Component of Hβ ([5] and [6]).
We show that an FWHM(FeIIλ4570) vs. FWHM(Hβ) correlation is highly significant for a large sample of AGN, but takes a different form depending on FWHM(Hβ) and FeII intensity.

2 The Template

We analyzed 220 spectra of low-z quasars and luminous Seyfert 1 covering the Hβ spectral range. For each spectrum, we measured the FeII emission using a scaled and broadened template extracted from a high S/N spectrum of I Zw

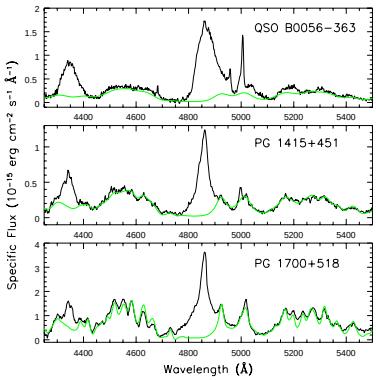

Figure 1: The Hβ region, with the FeII$_{opt}$ emission superimposed (thick green line).

1. This method has been already successfully applied by [7] and [8].
The template allows us to satisfactorily subtract the FeII emission to about 98% of the spectra of our sample. In other words, we found very few cases in which the line and multiplet FeII ratios deviate from the ones of I Zw 1.
Fig. 1 shows the successful rendering of the FeII$_{opt}$ emission by our template for three objects with very different line width.

3 FWHM(FeIIλ4570) vs. FWHM(Hβ)

Measurements of the FeII width are not trivial. To obtain a reliable estimate of the FWHM of FeII$_{opt}$ lines we performed the following operations. (1) We defined the local continuum using the regions around 4200, 4700 and 5000 Å, which are relatively uncontaminated by FeII emission. (2) We subtracted our FeII template, scaled and broadened to obtain minimum residuals in correspondence of the FeII blend centered at 4570 Å. (3) At this point, we measured the broadening factor of the template, which is proportional to the FWHM(FeIIλ4570), since the line FWHM is much larger than the instrumental profile. (4) We usually estimated the FWHM uncertainty evaluating a matrix where residuals were shown as a function of FeII intensity and broadening factor; FWHM boundaries were set when residuals were significantly worse than for the best fit. FeII equivalent width and FWHM measurements reliability depends on S/N ratio and intrinsic width of emission. For a fixed S/N, there is a minimum W(FeII) for which the blends become undetectable (i.e., features are lost in noise or create a pseudo-continuum). FeII equivalent width measurements were obtained for 112 objects; for the remaining only an upper limit to W(FeII) was given. The FWHM was measured for most but not all of the 112 objects: especially when FeII$_{opt}$ emission was weak, it was not always

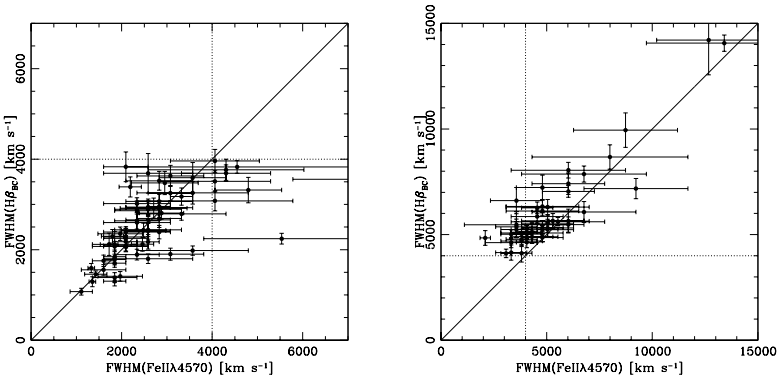

Figure 2: Comparison between FWHM(Hβ_{BC}) and FWHM(FeIIλ4570) for AGN of Pop. A (left) and Pop. B (right).

possible to constrain its width.
To accurately measure FWHM(Hβ_{BC}) we further subtracted the [OIII] emission at λ 4959 and λ5007 Å, interpolating between the blue and the red edges of the lines. Whenever the broad and/or narrow components of HeIIλ4686 were visible, they were subtracted using a Gaussian fit. Last, we subtracted the narrow component of Hβ also using a Gaussian profile.
Fig. 2 shows FWHM(FeIIλ4570) vs. FWHM(Hβ). There is a very well-defined correlation. Outlying data points are most likely due to poor S/N ratio, resolution and FeII weakness rather than to real differences. One case only is convincing: IRAS 07598+6508 (see §3.1).
The correlation takes a different form if FWHM(Hβ) $\leq$ 4000 km s^{-1} (Population A, according to [9]) or FWHM(Hβ) $\geq$ 4000 km s^{-1} (Population B):

- Pop. A. There is a tight correlation ($R_{Pearson} = 0.693,\ N = 69,\ P = 8.5 \times 10^{-9}$), with FWHM(H$\beta$) $\approx$ FWHM(FeIIλ4570). This implies that both emissions came from the same emitting region.
- Pop. B. Also in this case there is a clear correlation ($R_{Pearson} = 0.882,\ N = 43,\ P = 7.3 \times 10^{-9}$), but FWHM(H$\beta_{BC}$) seem to systematically exceed FWHM(FeIIλ4570).

3.1 A special case: IRAS 07598+6508

This intriguing object shows a FIR excess and its location in the so-called optical Eigenvector 1 diagram is peculiar ([10]). It is interesting to note that

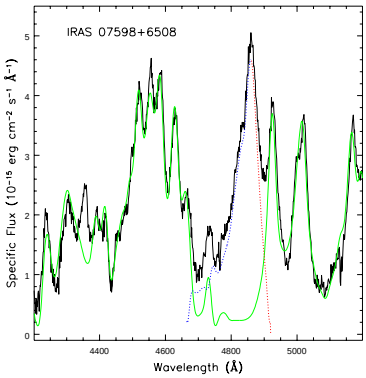

Figure 3: Hβ region of IRAS 07598+6508. The dotted blue/red line represents the Hβ_{BC}.

FWHM(Hβ_{BC})=5000±400 km s^{-1} and FWHM(FeIIλ4570)=2000±1300 km s^{-1}. The good S/N ratio and the strength of the FeII$_{opt}$ emission, along with the large EW(Hβ_{BC}), make this result especially striking. The strong blueward asymmetry of the BC of Hβ (see fig. 3) suggests that an additional broadening may be due to Balmer emission associated to the highly blueshifted CIVλ1549 Å emission). A narrower, unshifted component is to be associated to low ionization emission as in the rest of AGN.

4 Conclusion

The most straightforward implications of our results are that the FeII$_{opt}$ emission mechanism is probably the same in almost all AGN, and that FeII$_{opt}$ is emitted mainly from the zone of the BLR where Hβ is also emitted. The FWHM of FeII$_{opt}$ in Population B objects seems to be systematically narrower than that of the Hβ. This suggests that FeII emission in Pop. B sources may come from the outer part of Hβ emitting region, where the ionization degree is lower.

Acknowledgements

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